

Contemporary Physics I – HW 1

HW 1 Solution

1. You have the following vectors:

$$\begin{aligned}\vec{u} &= 12\hat{i} - 5\hat{j} \\ \vec{v} &= 3\hat{i} - 4\hat{j}\end{aligned}$$

Compute the following:

- (a) $3\vec{u} = 36\hat{i} - 15\hat{j}$
(b) $\vec{u} + \vec{v} = 15\hat{i} - 9\hat{j}$
(c) $|\vec{u}| = \sqrt{12^2 + 5^2} = 13$
(d) What angle does \vec{v} make with the x-axis?: $\theta = \arctan \frac{-4}{3} = -53.13^\circ = -0.927\text{rad}$
(e) $\vec{u} \cdot \vec{v} = (12) * (3) + (-5) * (-4) = 56$
(f) What is the angle between \vec{u} and \vec{v} ?: $\theta = \arccos \frac{\vec{u} \cdot \vec{v}}{|\vec{u}|*|\vec{v}|} = \arccos \frac{56}{13*5} = 30.51^\circ = 0.532\text{rad}$
2. Construct a vector of length, 10, which makes an angle $5\pi/6$ with respect to the x-axis.

$$\vec{r} = 10 * \cos \frac{5\pi}{6} \hat{i} + 10 * \sin \frac{5\pi}{6} \hat{j} = -8.66\hat{i} + 5\hat{j}$$

3. Consider a particle at position:

$$\vec{r} = 10m\hat{j}$$

moving with a constant velocity:

$$\vec{v} = 1m/s\hat{i} - 2m/s\hat{j}$$

After 3 seconds, how far will the particle be from the origin?

$$\vec{r}_f = \vec{r}_i + \vec{v}\Delta t = 10m\hat{j} + 3m\hat{i} - 6m\hat{j} = 3m\hat{i} + 4m\hat{j} \Rightarrow |\vec{r}_f| = 5m$$

4. A few quickies on the standard model:

- (a) Imagine I had a boson with a charge of +2. What quarks would comprise that? Is there a real such particle (look at your table)? What is it called?

To have a boson made up of quarks it needs to contain an even number of quarks. If you look at one proton it has 3 quarks (uud) and has a charge of +1, so if you take 2 protons (uud)+(uud) there is an even number of quarks and a charge of +2. You can also add to this 2 neutrons (udd)+(udd) and also be a boson with +2 charge and this is known as an α particle or a helium nucleus.

- (b) Draw a “Feynman Diagram” for a photon scattering off an electron. Turn that diagram on its side (90 degrees). What’s going on now?

See last page for solution.

- (c) Draw a Feynman diagram for a down-quark turning into an up-quark. Make sure that charge is conserved. What force is at work?

See last page for solution.

5. Consider a 2kg block. What is the momentum if the speed is: For these we use the formula $p = mv\gamma$

(a) 10 m/s ? The velocity is small so we can use $p \approx mv = 20 \frac{kgm}{s}$

(b) 400 m/s? The velocity is small so we can use $p \approx mv = 800 \frac{kgm}{s}$

(c) 2×10^8 m/s? Now we have to use the $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ factor: $p = 5.37 \times 10^8 \frac{kgm}{s}$

(d) 2.9×10^8 m/s? We again have to use γ : $p = 2.27 \times 10^9 \frac{kgm}{s}$

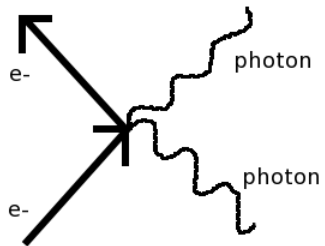
6. 1.HW.95 (in your textbook, naturally)

$$\vec{p} = m\vec{v} = 15.2 \frac{kgm}{s} \hat{i} + 0 \frac{kgm}{s} \hat{j} - 10.8 \frac{kgm}{s} \hat{k} \Rightarrow |\vec{p}| = 18.64 \frac{kgm}{s}$$

7. 1.HW.100

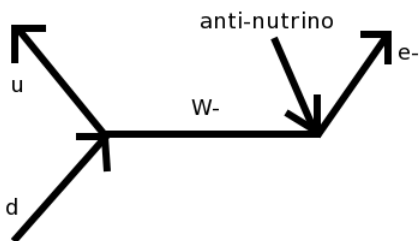
$$\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t} = 50 \frac{m}{s} \hat{i} - 20 \frac{m}{s} \hat{j} + 20 \frac{m}{s} \hat{k}$$

4. (b)



If you turn this by 90 degrees you get an electron and a positron turning into photons.

4. (c)



This is the weak force at work.